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INFLUENCE OF PLANT HEALTH CLINIC DIAGNOSTIC SERVICES ON POTATO PRODUCTION AMONG SMALLHOLDER FARMERS OF MOLO SUB-COUNTY, KENYA

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Original Article

ABSTRACT

Plant health clinics are primarily responsible for diagnosing plant ailments and providing remedial measure to reduce crop losses and improving food security through diagnostic services among farmers. Globally pests and diseases cause massive losses among farmers. It is believed that by reducing crop losses and increasing yields millions of people can be fed. The objective of this study was to determine the influence of plant health clinic diagnostic services on potato production among smallholder farmers in Molo Sub-County, Kenya. The study engaged 152 smallholder potato farmers randomly sampled from Mariashoni, Molo, Elburgon and Turi wards of Molo Sub County and 10 key informants, mainly officers of agriculture in the area. Data was gathered through administration of questionnaires and key informant interviews. The data was analyzed using both qualitative and quantitative techniques. The hypotheses were tested using multiple regression analysis. The findings indicated that frequency of receiving diagnosis, use of diagnostic services and perception of the role of diagnostic services significantly influence potato production among smallholder farmers [p =0.018, p = 0.016 and p = 0.000] with adjusted R^2 = 0.590. The study concluded that frequency of receiving diagnosis, perception of the role of diagnostic services and use of diagnostic services are vital services in potato production. The study therefore recommends that plant health clinic diagnostic services on potato production should be put more emphasis on. This ensures sustainability of potato production efforts in smallholder potato production.

KEYWORDS: Use of Diagnostic Services, Frequency of Receiving Diagnosis, Multiple Regression Analysis & Potato Production

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INTRODUCTION

Globally crop pests and diseases are common and important threats to agricultural production (Trebicki & Finlay, 2019). Similarly, in Sub-Saharan Africa crop pests and diseases are major limiting factor of growth in agricultural production thus threatening the livelihoods of farmers in the region (Savary et al., 2019). It is estimated that crop losses due to pests and diseases are about 50 % across Sub-Saharan Africa (Ratnadass, 2020). Therefore, any loss on their crops caused by pests and diseases can have distressing effects on the livelihoods of the people who largely depends on it for food and income. As Gehen et al. (2019) points out losses due to pests and diseases can be substantial and may be prevented, or reduced, by crop protection measures. It is hence, important to provide extension services to farmers with options that are context-specific to their agricultural conditions and socioeconomic circumstances to address pests as well as diseases outbreaks (Heeb et al., 2019).

Extension services are effective in forecasting agricultural problems outbreaks, consequently permitting time for development and application of proper mitigation measures (Coyne et al., 2018). Contrary to extension services contribution, the traditional supply-driven and top-down nature of service delivery in extension has been inefficient in meeting the specific needs of the smallholder farmers in many developing countries such as Kenya (Kalimba & Culas, 2020). They often fail to reach and address the diverse needs of resource-poor farmers. Besides reaching out to a large number of smallholder farmers in many of these countries has been a challenge owing to the nature of service delivery of traditional supply-driven and top-down extension services (Álvarez-Mingote & McNamara, 2018). This could be attributed to the fact that traditional supply-driven and top-down approaches tend to be biased towards specific areas and crops, and are not flexible enough to support farmers who have to cope with the unpredictable changes and emerging challenges faced by the varied range of crops they grow (Rajkumar & Anabel, 2018). These weaknesses have led to calls for demand-driven approach in providing efficient extension services such as plant health clinic.

Plant health clinics concepts evolved as scientists were in the trial of exploring ways of giving support to farmers who were looking for advice on crop health problems (Danielsen & Kelly, 2015). Since then, the plant health clinics have extended rapidly to over 34 countries across Asia, America, and Africa (CABI, 2020). In Kenya plant health clinics began operating in 2010 and since then they have been convened to address challenges within agriculture such as those concerning crop health (Sluijs, et al., 2017). The plant health clinic services such as diagnostic try to responds to farmers demand for plant health diagnosis to solve plant health problems (Musebe et al., 2018). According to Ghaiwat and Arora (2014) diagnosis of plant diseases and pests is very essential at an earlier stage in order to cure and control them. Early and accurate detection of plant diseases in addition to pests are key factors in crop production and the reduction of both qualitative as well as quantitative losses in crop (Toroitich, 2017). For instance, pests and disease forecasts through diagnosis play an important role in determining when to use pesticides, how to use it and the amount to use. This saves farmer waste of resources and helps minimize costs alongside protection of environment.

Study by Jowi (2018) have also shown how the plant doctors through the diagnostic services offer farmers information on detection, identification, examination, monitoring of pests and diseases. In addition, Kansiime et al. (2020) note that diagnostic services have been playing an important role in improving farmers' access to real-time, reliable, and relevant diagnostic, that promote crop health by reducing incidences of crop pests and diseases. Despite these contributions and efforts by the plant health clinic diagnostic services to appropriately help farmers identify, detect, monitor and address pests and diseases early before they cause devasting crop losses therefore improving crop production, there is lack of empirical evidence on whether plant health clinic diagnostic services are achieving this objective particularly in potato production in Kenya which is a vital sector.

In Kenya potato is the second most important food crop after maize and a major staple food and cash crop among potato growing communities (Kimathi et al., 2021). The sector also employs approximately 3.3 million people along the potato value chain (Bolt et al., 2019). Potato equally provides significant income opportunities as well as food for smallholder farmers and additionally contributes to poverty alleviation through income generation in both urban and rural households Mburu et al., 2020). In the Counties like Nakuru potato production sector has the high potential of addressing unemployment as well as food security (Mutinda, 2020). Potato production also is a valuable enterprise for smallholder farmers in Molo Sub County contributing positively towards the food and income levels (Kamau, 2019). In spite of potato production playing a major role in food production and cash income farmers especially smallholders are still recording low

production compared to potential (Gebru et al., 2017).

As pointed out by Ebrahim et al. (2018) a number of problems continue to threaten potato leading to low production. Among the factors attributed to low yields include; traditional production systems, shortage of quality seeds, decline soil fertility, poor agronomic practices, a disorganized marketing system, high incidence of pests and diseases, lack of clear policies on packaging, poor technology transfer and low use of quality agro-inputs (Gebru et al., 2017). However, the high incidence of pests and diseases have been estimated to cause 80% reduction in production therefore threatening overall yields (Centre for Agriculture and Bioscience International [CABI], 2020). Minimizing loses due to pests and diseases to increase yields as noted by Heeb et al. (2019) would be possible through providing farmers with demand-driven diagnostic extension services which help them address pests and diseases outbreaks.

Plant health clinic diagnostic services notably have been found to reach and provide diagnosis services to farmers using a demand-driven approach on a similar method to human health clinic (Musebe et al., 2018). According to Lamontagne-Godwin et al. (2019) plant health clinic diagnostic services have been recognized as innovative in aiding farmers to deal with crop diseases and pests diagnosis by responding to individual farmer's needs. Therefore, as a drive towards solution findings, it is prudent that influential services such as plant health clinic diagnostic likely to affect potato production be analyze (Otieno et al., 2020). Although, various scholars have undertaken substantial research on factors influencing potato production, none of these studies have examined the potential of plant health clinic diagnostic services in addressing potato production especially among smallholder farmers in Molo Sub-County, Kenya.

The existing studies on the impact of plant health clinics diagnostic services have mostly focused on outcomes related to technology adoption, crop productivity and household welfare (Bentley et al., 2011; Silvestri et al., 2019; Tambo et al., 2021). The current study attempts to fill this knowledge gap by determining the influence of plant health clinic diagnostic services on potato production. The study focused on a demand-led extension approach that provides plant health diagnostic services to farmers. This study aimed at determining influence of plant health clinic diagnostic services on potato production among smallholder farmers in Molo Sub-County, Kenya. Insights gained from this study can be useful in informing policy efforts aimed at reducing potato losses due to pests and diseases, thereby increasing food production particularly potato.

MATERIALS AND METHODS

1. Study Area

The study was conducted in Molo Sub-County, Kenya, which is one of the eleven Sub Counties making up Nakuru County (County Government of Nakuru, 2018). Administratively, Molo Sub County has four wards namely, Mariashoni, Elburgon, Turi and Molo (Figure 1). The Sub County covers a total area of 478.79 KM^2 and a population of 156,732. Molo Sub-County is located in the Rift Valley along the Mau Forest, which runs on the Mau escarpment (Kenya National Bureau of Statistics [KNBS], 2019). It is situated at 0.25° South latitude, 35.73° East longitude and 2534 meters above sea level. The area is categorized as cold with the average temperatures of 14.1°C and an average rainfall of 1131 millimeters. Its geographical position makes it a suitable place for growing potato among other crops. The main economic activities in this area include crop farming [main crops are maize, pyrethrum, potato, and barley], dairy, and sheep rearing (Kamau, et al., 2020b). The area was selected because of its high potential in potato production (Maingi et al., 2020).

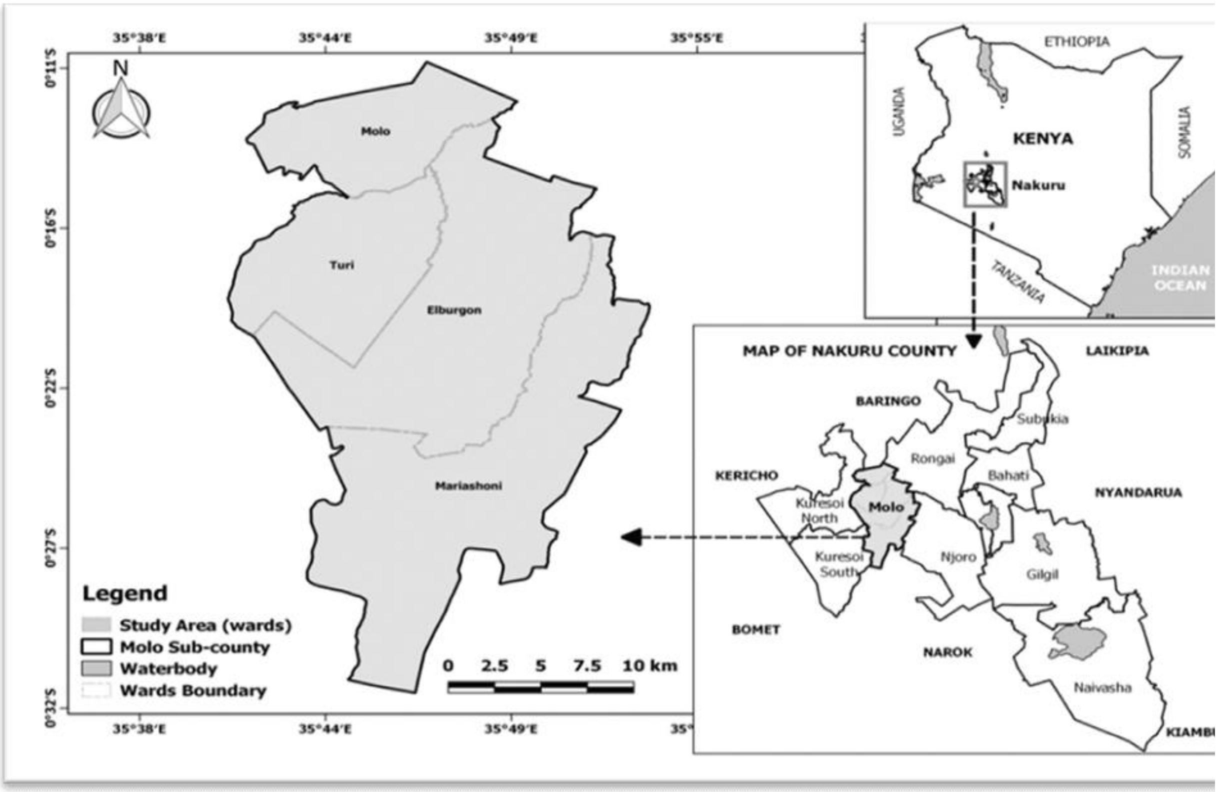

Figure 1: Map Showing the Location of the Study Area.

2. Sampling Procedure

The study followed a purposive sampling technique in which Molo Sub-County was purposively selected based on the magnitude of potato production. Secondly, the four wards Elburgon, Molo, Turi and Mariashoni were selected due to their importance in potato production in the Sub County. Proportionately, the sample was distributed among the four wards (Table 1). Simple random sampling procedure was then used to select respondents with relatively similar characteristics to be involved in the study from each of the four wards. Purposive sampling was also used to select the 10 key informants who included Sub-County agricultural officer, Sub-County crop development officer, 4 Ward Crop development officers, and 4 plant doctors.

3. Sample Size Determination

The required sample size of smallholder potato farmers was determined using the formula recommended by Nassiuma (2000), for determining the sample size. The formula is given by;

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where:

n= is the required sample size,

N=is the population within the study area,

C= is the Coefficient of variation,

E=is the Standard error value

Nassiuma (2000) declares that in most surveys or experiments, a coefficient of variation is in the range of 21% ≤ C ≤ 30% and standard error in the range of 2%≤ e ≤ 5% is usually acceptable. Therefore, a coefficient of variation of 25% and standard error of 2% was used for this study. The lower limit of the standard error is selected to ensure low variability in the sample and minimize the degree or error. For this study N=6,000 smallholder potato farmers C =25% and e =2%

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

$$n = \frac{6000 \times (0.25)^2}{(0.25)^2 + (6000-1)(0.02)^2} = 152$$, this was, distributed per ward as shown in Table 1.

Table 1: Distribution of Sample Respondents in the Study Area

Ward	Population Size Distribution	Proportionate (%)	Sample size
Elburgon	1050	17.5	27
Mariashoni	1610	26.83	41
Molo	1340	22.33	33
Turi	2000	33.33	51
4	**6000**	**100**	152

4. Data Collection Methods and Data Analysis

Data was collected through administration of questionnaires and key informant interviews. Data was then coded and analyzed using *Statistical Package for Social Sciences (SPSS)* data management software version 22, while qualitative data was analyzed by establishing the themes in line with the study objective. To test the statistical significance of the findings of this study and establish influence between independent (plant health clinic diagnostic services [perception of role of diagnostic services, use of diagnostic services and frequency of receiving diagnosis]) and dependent variable (potato production), multiple regression analysis was used.

RESULTS AND DISCUSSION

1. Sources of Diagnostic Information on Potato Health by the Respondents

Results in Figure 2 shows that the majority of the respondents 81.6 % and 77.6 % obtained potato health diagnostic information from plant health clinic and government extension officers respectively, 30.9 % from NGOs, 32.2 % from agro-input dealers, 32.9 % radio, 25% Television programs, 35.5 % from family, friends and neighbors, 37.5% from group members, while 13.2 % from magazines/newspapers and internet respectively. This implies that plant health clinic diagnostic services and government extension officers play a key role in the region. The key informants' responses were in line with the findings by smallholder potato farmers that major providers of diagnostic information in the area were plant health clinic and government extension officers. These results are consistent with those of Rajendran and Islam (2015) who conducted a study documenting the impact of plant health clinic in Bangladesh among farmers and observed that majority of farmers obtained plant health diagnostic information from government extension officers and plant health clinic.

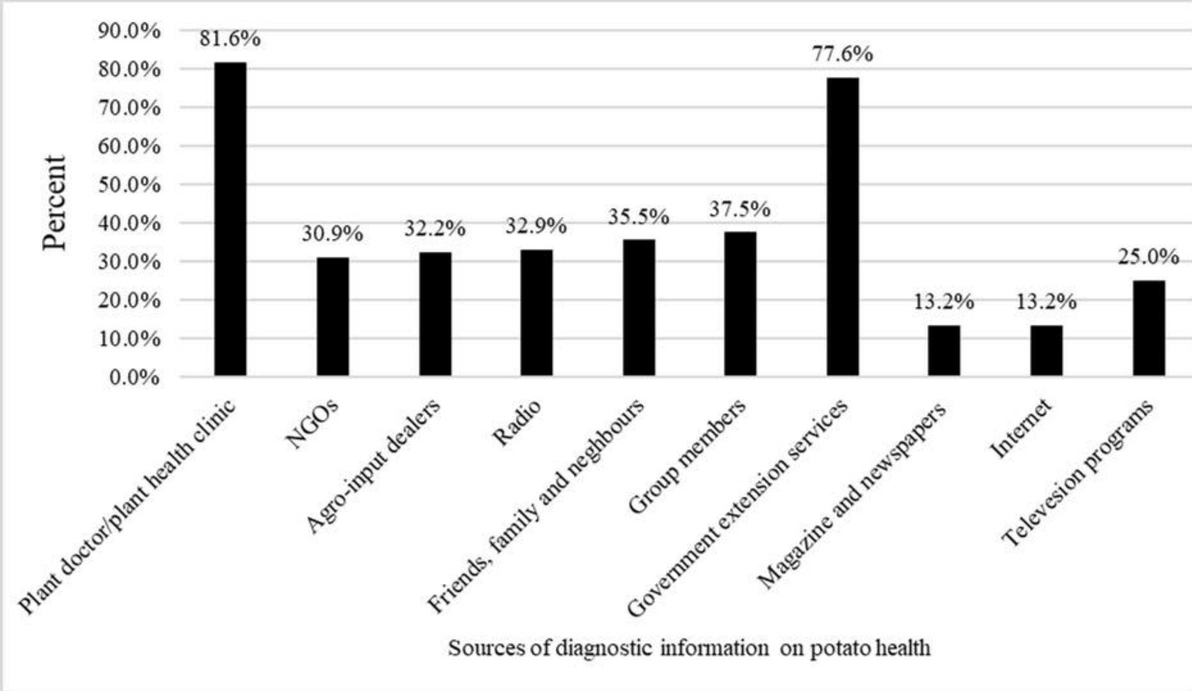

Figure 2: The Major Plant Health Diagnostic Information Providers in the Production of Potatoes in the Study Area.

2. Frequency of Receiving Diagnosis

Study results in Figure 3, indicated that 28% of the respondents reported to have received diagnosis once, 30% reported to have received diagnosis twice, 12 % reported to have received diagnosis thrice, only 4 % reported no diagnosis received, 8 % reported to have received diagnosis four times, 11 % reported to have received diagnosis more than five times whereas 7 % reported to have received diagnosis five times. Key informants interviews results agreed with this, they stated that farmers seek diagnosis once mostly per year during their crop production. Similar result from Murithi et al. (2013) showed that most farmers received training once and twice during the annual year they carry out crop production.

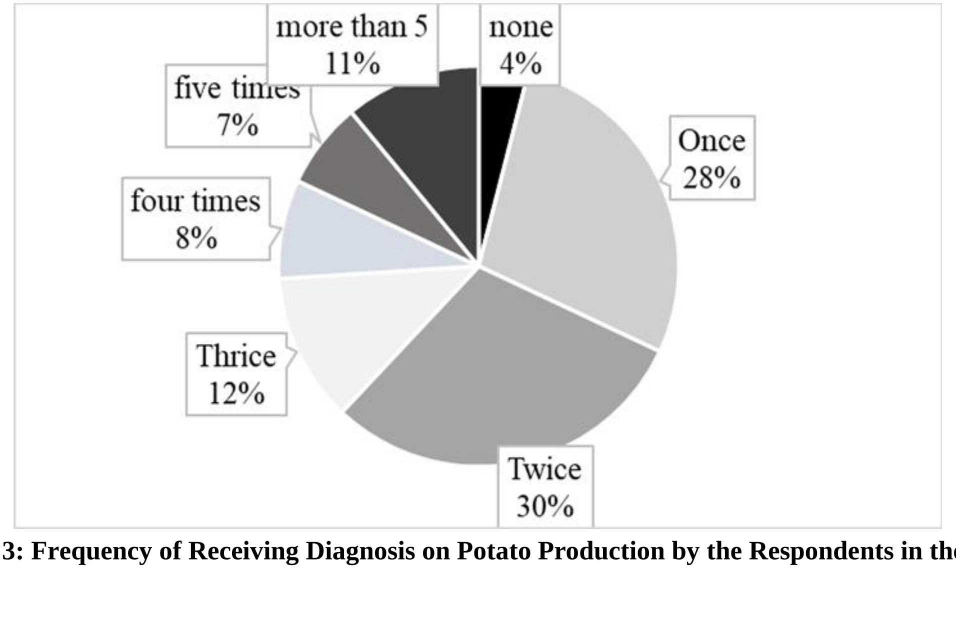

Figure 3: Frequency of Receiving Diagnosis on Potato Production by the Respondents in the Area.

3. Perception of the Role of Diagnostic Services by the Respondents in the Study Area

The perception of the role of diagnosis services from plant health clinic in improving potato production was measured using closed ended 5-Likert scale (1= strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). Neutral meant that the respondent is not sure (neither disagree or agree). Strongly Agree meant that the respondent strongly agree with the statement. Agree meant that the respondent agree to the statement. Strongly Disagree meant that the respondent strongly disagrees with the statement, while disagree meant that the respondent somehow disagrees with the statement. The results in Table 2 shows that majority 34 % and 26% agree and strongly agree that diagnosis services enable farmers to detect and identify pests respectively. Most of the respondents 41% agree that diagnosis services enable farmers to describe the condition and damage of pests, high % (43) agree that diagnosis services enable farmers to monitor and manage pests. 28% strongly agrees that diagnosis services enable farmers to detect and identify diseases, while only less than 5% disagree and strongly disagree of the role of diagnosis. In addition, key informants from the interviews agreed about the great role played by diagnostic services in improving potato production. Diagnostic services from plant health clinic have been found to be associated with crop production because of its potential to influence access to knowledge and skills that aimed at reducing crop losses and improving production (Danielsen et al.,2014). Diagnostic services significantly increased the ability of farmers to identify and address crop health problems, increasing their knowledge and ability to communicate crop problems and address crop problems by themselves (Rajendran & Islam, 2017). Early and accurate detection of plant diseases are key factors in crop production and the reduction of both qualitative as well as quantitative losses in crop (Toroitich, 2017).

Table 2: Statement of Perception Towards the Role of Diagnosis on Potato Production in the Study Area

	Strongly Disagree		Disagree		Neutral		Agree		Strongly agree	
N=152	F	%	F	%	F	%	F	%	F	%
Enable farmers to detect and identify pests	5	3	4	9	41	27	52	34	40	26
Enable farmers to describe the condition and damage of pests	4	3	8	5	43	28	62	41	35	23
Enable farmers to monitor and manage pests	5	3	3	2	38	25.0	66	43	40	26
Enable farmers to detect and identify diseases	3	2	1	0.7	41	27.0	65	42	42	28
Enable farmers to describe the condition and damage of diseases	3	2	7	5	42	28	66	43	34	22
Enable farmers to monitor and manage diseases	2	1	4	3	35	23	67	44	44	29

4. The Influence of Plant Health Clinic Diagnostic Services on Potato Production

To determine influence of plant health clinic diagnostic services on potato production the hypothesis that stated that *there is no statistically significant influence of plant health clinic diagnostic services on potato production among smallholder farmers in Molo Sub-County, Kenya* was tested by applying multiple regression analysis. The multiple regression was in the form of;

$$Y_i = b_0 + b_1X_1 + b_2X_2 + b_3X_3$$

where; X_1 = frequency of receiving diagnosis, X_2 = use of diagnostic services, X_3 = perception of the role of diagnostic services. The results on regression analysis were as shown in Table 3, 4 and 5.

Table 3: Regression Analysis between Plant Health Clinic Diagnostic Services and Potato Production

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.769[a]	.591	.590	0.809151	.591	71.335	3	148	.000

From Table 3, the adjusted R-squared for the relationship between plant health clinic diagnostic services and potato production among smallholder farmers in Molo Sub-County, Kenya was 0.590. This implies that plant health clinic diagnostic services explain 59.0 % of variation in potato produced.

Table 4: Analysis of Variance between Plant Health Clinic Diagnostic Services and Potato Production

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	857.311	3	285.770	71.335	.000[b]
	Residual	592.894	148	4.006		
	Total	1450.205	151			

Analysis of variance was used to assess whether the model was fit for the collected data. The ANOVA table (Table 4) indicates p-value = 0.000, which is less than 0.05. This shows that the model is reliable in determining how the independent variable, plant health clinic diagnostic services influence potato production in Molo Sub-County, Kenya. Further, the F (3, 148) = 71.335, P = 0.000 thus this indicates that the model was fit for looking into the influence of plant health clinic diagnostic services on potato production.

Table 5: Multiple Regression Analysis of Plant Health Clinic Diagnostic Services and Potato Production

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.177	.499		2.356	.000
	Frequency of receiving diagnosis	0.144	.108	.085	1.337	.018
	Use of diagnostic services	1.114	.456	.144	2.444	.016
	Perception of the role of diagnostic services	4.038	.347	.679	11.639	.000
a. Dependent Variable: Potato production b. Predictors: (Constant), Perception of the role of diagnostic services, Frequency of receiving diagnosis, Use of diagnostic services						

The results in Table 5 shows that frequency of receiving diagnosis, perception of the role of diagnostic services and use of diagnostic services had an influence on potato production at p = 0.018, p = 0.000 and p = 0.016 respectively which were less than level of significance 5%. The unstandardized coefficients show frequency of receiving diagnosis, use of diagnostic services and perception of the role of diagnostic services had a positive contribution on potato production at 0.144, 1.114, and 4.038 respectively. A unit increase in frequency of receiving diagnosis will lead to a 0.144 tons per hectare increase in potato production if all other variables are kept constant, while a unit increase in use of diagnostic services would lead to 1.144 tons per hectare increase in potato production taking all other variables constant. Perception of the role of diagnostic services $b_3 = 4.038$ will lead to 4.038 tons per hectare increase in potato production taking all other variables constant.

Based on these results the equation relating plant health clinic diagnostic services and potato production was

$Y= 1.177+ 0.144X_1 + 1.114X_2 + 4.038X_3$

Where;

Y = potato production; X_1 = frequency of receiving diagnosis; X_2 = use of diagnostic services; X_3 = perception of the role of diagnostic services

From the results in the Table 5 it further reveals that the variables frequency of receiving diagnosis, use of diagnostic services and perception of the role of diagnostic services with p values of $p = 0.018$, $p = 0.016$ and $p = 0.000$ respectively were significant at 5% level of significance. Therefore, the study null hypothesis that there was no statistically significant influence of plant health clinic diagnostic services on potato production in Molo Sub-County was rejected. These findings concur with other studies that found out that frequency of diagnosis and use of diagnostic services among farmers statistically and significantly relate with production. For example, Tambo et al. (2021) found that frequency of diagnosis received by the farmers significantly influenced maize production in Rwanda. They are also in agreement with a study done in Bolivia by Bentley et al.(2011) that confirmed that frequency of diagnosis make an appreciable contribution to crop production. Further the findings are in support of a study by Uzayisenga et al. (2015) that found out that use of plant health clinic diagnostic services impact on farmers' production. The findings also are in line with that of Srivastava (2013), that farmers production is related to use of plant health clinic diagnostic services which enable farmers manage and control diseases and pests.

The study findings on the perception of the role of diagnostic services are in line with the findings by Mangini (2012), who noted that the degree of perception of role of diagnostic services of the farmer significantly affect their degree of seeking for these services therefore learning how to improve crop production. They explained that perception of role of diagnosis is a determinant for tendency to seek for these services which help them gain skills and knowledge for them to manage a problem early, when it is relatively simple and inexpensive to treat and before extensive damage occurs. The findings also conform to those of Murithi et al. (2013) who also found that use of plant health clinic diagnostic services is important in diagnosing disease and pest for early management and control to avoid yield loss by farmers in Embu County, Eastern Kenya.

According to Rajendran and Islam (2017) use of diagnostic services significantly increase farmers ability to detect, identify and address crop problems which effectively improve production due to crop protection. Danielsen and Matsiko (2016) proclaims that plant health clinic diagnostic services are effective key contributor of improving production among farmers through helping farmers in handling crop health problems and crop management practices. Additionally, Srivastava (2014) reported that through plant health clinic diagnostic services farmers get timely diagnosis of their crops and are well placed to cope with the crop loss early before distressing loss.

CONCLUSIONS

Conclusively, frequency of diagnosis from plant health clinic, perception of the role of diagnostic services and use of diagnostic services empowers potato production of smallholder farmers. Therefore, it becomes important to enhance use diagnostic services, perception of the role of diagnostic services and frequency of plant health clinics diagnostic services among smallholder potato farmers. It is important to empower smallholder potato farmers with latest know-how and innovations on production technology and information technology through these services. Smallholder potato farmers

should be sensitized to utilize plant health clinic diagnostic services in potato production to improve production through enhancement of pests and diseases resilience.

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